

MAXIMUS: Exploiting the Full Power of OzPoz

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Abstract. We propose a new multi-object spectrograph for the VLT. MAXIMUS (MAXimum MULTiplex Spectrograph) will fully exploit the multiplexing capabilities of the OzPoz fibre positioner in order to extend and complement FLAMES and VIMOS in covering observational parameter space, and to meet the increasing demand for multi-object spectroscopy by ESO users in the next decade.

1 The OzPoz fibre positioner

The OzPoz fibre positioner is being built by the AUSTRALIS consortium (consisting of the Anglo-Australian Observatory, the Australian National University and the University of New South Wales) for the FLAMES fibre-spectroscopy facility on the VLT (<http://www.eso.org/instruments/flames/OzPoz.html>).

OzPoz allows full access to the 25 arcmin diameter (0.136 deg^2) field of view of the VLT Nasmyth focus. It offers four field-plate positions, only two of which are used by GIRAFFE and UVES – the other two positions are currently unused. Up to 600 single-object fibres can be mounted on each field-plate, and the positioning robot is capable of configuring all 600 fibres in 50 minutes. As well, OzPoz handles multiple deployable fibre integral field units (d-IFUs), which can be as numerous as detector area allows.

2 Exploiting OzPoz

There are two main ways in which the capabilities of OzPoz could be fully exploited by new VLT instrumentation.

One way is essentially an **upgrade** option for FLAMES, leaving the existing feeds to GIRAFFE and UVES spectrographs in place and utilising the two free field plates to feed a new spectrograph. Each of the two new field plates would hold 560 single 1 arcsec diameter fibres and also 15–20 d-IFUs each with 127 0.3 arcsec fibres giving a 4 arcsec diameter field.

The other option is a full-fledged **second-generation instrument** for the VLT, and would use all four of OzPoz’s field plates. In this case one would have more flexibility in the mix of single fibres and d-IFUs. For example, one might chose to have two plates with 600 single 1 arcsec diameter fibres and two plates with 60–80 d-IFUs with 2 arcsec diameter fields ($37 \times 0.3 \text{ arcsec}$); many other arrangements (particularly for the d-IFUs) are also possible.

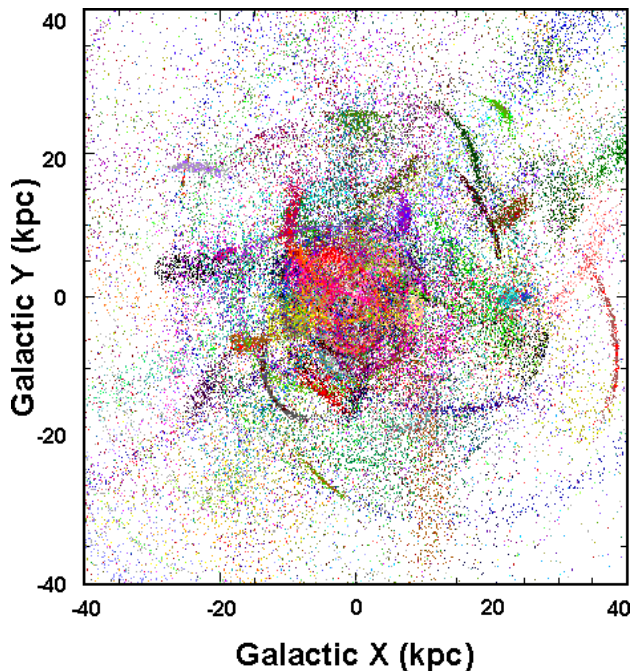


Fig. 1. Simulation of the tidal streams of stars accreted into the Galactic halo.

3 Science Drivers for MAXIMUS

The scientific demand for multi-object spectrographs is so strong that every single 8-metre telescope (not just every 8-metre observatory) will have at least one: Gemini North and South both have a GMOS (also FLAMINGOS-II); Keck I+II will have LRIS multislits, DEIMOS and KIRMOS; MMT will have Hectospec; Subaru will have FMOS. The four VLT unit telescopes will have FLAMES, VIMOS and NIRMOS. The new deep, wide-field imaging surveys in the visible, UV, IR, X-ray and radio will only increase the demand for deep, wide-field, multi-object spectroscopy on 8-metre telescopes. Spectroscopic follow-up of surveys carried out with VISTA will be particularly important to VLT users.

With such a plethora of multi-object spectrographs, it is important for new instruments to have distinguishing advantages. MAXIMUS aims to provide VLT users with the maximum multiplex advantage allowed by the OzPoz fibre positioner, for both unresolved single-fibres and small, deployable integral fields. The science drivers are observations that require either: (i) the highest possible multiplex gain for unresolved single-object spectroscopy over the widest possible field of view, or (ii) high-multiplex resolved spectroscopy over a few square arcseconds with seeing-limited sampling over the widest possible field of view.

An example of a Galactic programme driven by a wide field and maximum multiplex is the attempt to recover the merger history of the Galaxy's halo by

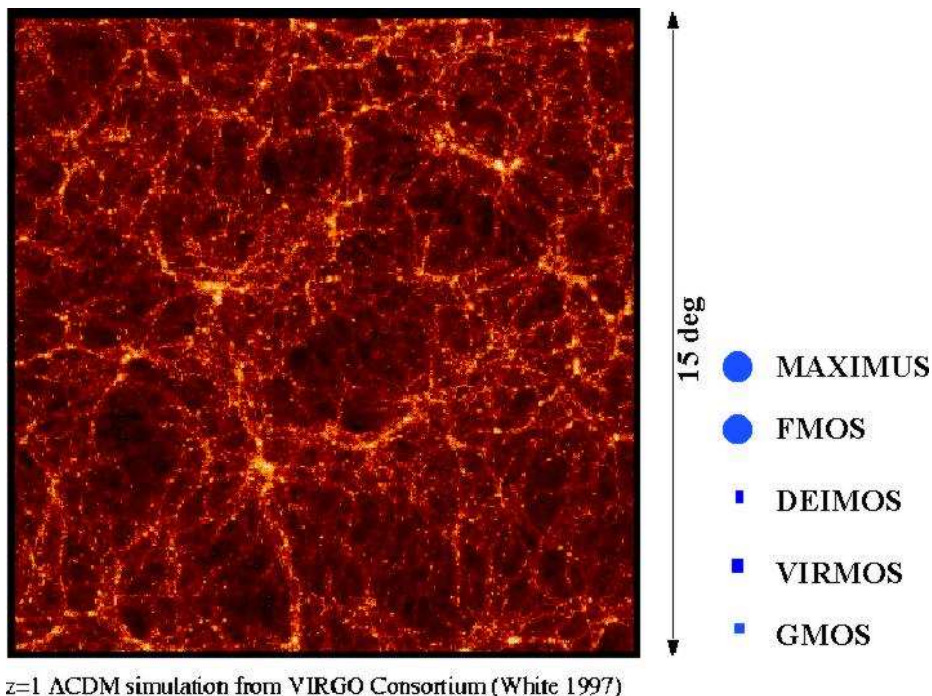


Fig. 2. Simulation of the large-scale structure at a redshift $z = 1$ by the Virgo Consortium [2], and the relative fields of view of various multi-object spectrographs.

mapping the tidal streams of the accreted stars. Figure 1 shows a simulation of these stellar streams in what has been aptly referred to as the spaghetti model for halo formation [1]. It is immediately apparent that only a densely-sampled wide-field survey of stellar velocities (requiring a high-multiplex, wide-field spectrograph with good spectral resolution) will be able to unravel the complex structure of the halo.

Similar instrumental requirements are demanded by surveys of the evolution of large-scale structure at high redshift. Figure 2 shows the fields of view of multi-object spectrographs on 8-metre telescopes compared to a simulation of the large-scale structure in the galaxy distribution at a redshift of $z = 1$ [2]. Again, it is readily apparent that a high-multiplex, wide-field spectrograph will be essential for mapping these structures on the scales of interest.

4 Conceptual designs for MAXIMUS

We propose two possible conceptual designs for MAXIMUS:

Design #1, shown in the top panel of Figure 3, has a curved fibre slit with a fish-tail design that sends the light from half the fibres to one side of the collimator and half to the other. The fibre apertures are approximately 1 arcsec.

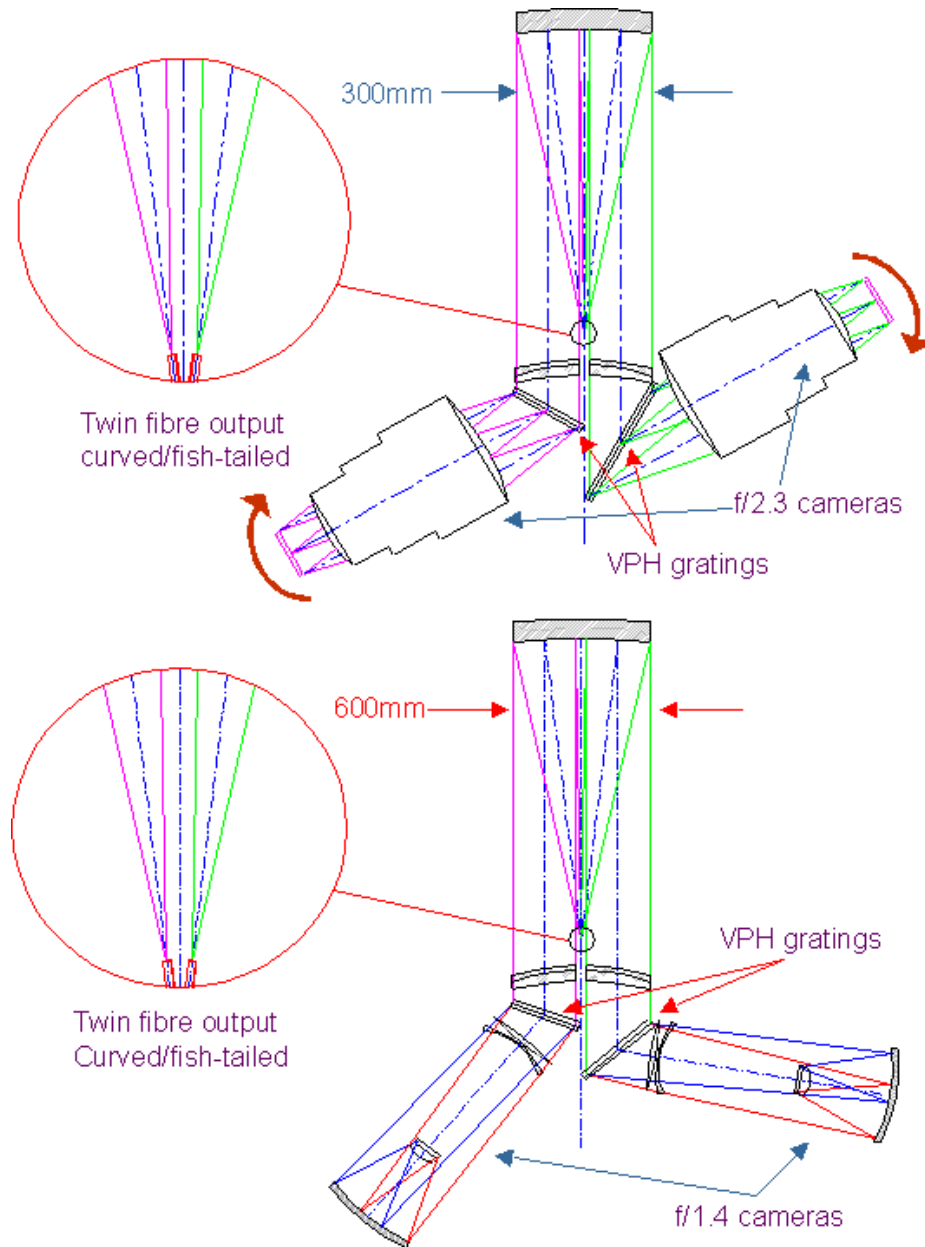


Fig. 3. Conceptual designs for MAXIMUS – design #1 above and design #2 below.

The two parallel collimated beams, each of diameter 150 mm are sent to two volume phase holographic (VPH) gratings. Two articulated cameras view the VPH gratings in the Littrow transmission configuration. Each camera has an F/2.3 dioptic design and feeds an 8k×8k CCD detector mosaic. Each of the two spectrograph arms takes the light from 300 single fibres or 40 d-IFUs.

Design #2, shown in the bottom panel of Figure 3, is generally similar, except that the two parallel collimated beams are each of diameter 300 mm and the camera has an F/1.4 catadioptic design. This allows the use of a smaller 4k×4k CCD detector. Each of the two spectrograph arms takes the light from 300 single fibres or 30 d-IFUs.

5 Comparison with other VLT facilities

MAXIMUS extends the capabilities of GIRAFFE by offering a wider range of spectral resolutions: $R \sim 1800\text{--}30000$ compared to GIRAFFE's $R \sim 5000\text{--}20000$. The lower resolutions in particular will make MAXIMUS much more useful for extragalactic observations. MAXIMUS has the same field area (0.136 deg^2), but a $4.5\times$ higher multiplex for single fibres (600 vs 132). MAXIMUS also offers 60–80 deployable IFUs each with a field of view of 2 arcsec diameter at 0.3 arcsec resolution, compared to GIRAFFE's 15 deployable IFUs each with a field of view of $3\text{ arcsec} \times 2\text{ arcsec}$ at 0.6 arcsec resolution. By using volume phase holographic gratings, MAXIMUS should achieve 30% higher throughput than GIRAFFE (excluding detector differences).

MAXIMUS complements the capabilities of VIMOS by offering $10\times$ the spectral resolution ($R \sim 1800\text{--}30000$ vs $R \sim 200\text{--}2500$) and $2.2\times$ the field area (0.136 deg^2 vs 0.062 deg^2). MAXIMUS gives a similar multiplex to VIMOS at low resolution (600 vs 800) at lower surface density (1.0 deg^{-2} vs 3.6 deg^{-2}); at high resolution it provides $3\times$ higher multiplex (600 vs 200) at comparable surface density (1.0 deg^{-2} vs 0.9 deg^{-2}). The IFU facilities offered are also complementary: for MAXIMUS, 60–80 deployable IFUs with field of view 2 arcsec diameter at 0.3 arcsec resolution vs the single large VIMOS IFU.

6 A near-infrared version of MAXIMUS

A near-infrared version of MAXIMUS (design #3) can also be envisaged. This design is similar to design #1, using F/2.3 dioptic cameras with 4k×4k HgCdTe detectors that would be interchangeable with the optical cameras. The individual object apertures would again be about 1 arcsec in diameter, but in this design would consist of a 7-hex-format fibre bundle, allowing about 250 single objects or 20 deployable IFUs to be accommodated in each spectrograph.

This NIR version of MAXIMUS would significantly extend the capabilities of NIRMOS. It would offer $3.2\times$ the spectral resolution ($R \sim 8000$ vs $R \sim 2500$), guaranteeing effective avoidance of the OH sky lines. It would also have a $2.2\times$ larger field area (0.136 deg^2 vs 0.062 deg^2) and $2.8\times$ the multiplex at moderate resolution (500 vs 180). It would in addition offer 40 deployable IFUs, each with

a field of view of 2 arcsec diameter at 0.3 arcsec sampling. Both MAXIMUS and NIRMOS would have the same long-wavelength limit of around $1.6\mu\text{m}$ due to their non-cryogenic design.

References

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